Table 1. Properties of selected semiconductors at room temperature 300 K

Material	Atomic/ Molecular weight	Bandgap E_g(eV) at 300K	Lattice parameters *a*, *c* (Å)	Melting point (°C)	Thermal conductivity ($mWcm^{-1}K^{-1}$)	Mobility μ ($cm^2V^{-1}s^{-1}$)		Dielectric constant ε_0
						Electron	Hole	
Group IV								
C (Diamond)[Dd]	12.01	5.47[I]	3.567	3577	30,000	1800	1200	5.7
4H-SiC [W]	40.1	3.2[I]	4.360	1800	4900	800	115	9.7
6H-SiC [W]		3.0[I]	3.08, 15.12	1800	4900	370	90	9.7
3C-SiC [Z]		2.2[I]	4.360	1800	5000	750	40	9.7
Si [Dd]	28.09	1.12[I]	5.431	1415	1500	1500	450	11.9
Ge [Dd]	72.6	0.66[I]	5.646	937	600	3900	1900	16.2
α-Sn [Dd]	118.69	0.08	6.4912	505.2	640	2500	2400	
III-V								
BN [Z]	24.82	4.6	3.615	3300	200			
BP [Z]	41.78	2.1	4.538	2800		500	70	
BAs [Z]	85.73	1.5	4.777	2300				
AlN [Z]	40.99	5.11[D(theory)]	4.38	2400	823	-	-	8.5
[W]		6.2	3.112, 4.982		2000			
AlP [Z]	57.95	2.46[I]	5.451	1870	900	60	-	9.8
AlAs [Z]	101.90	2.16[I]	5.665	1740	910	294	420	10.06
AlSb [Z]	148.73	1.58[I]	6.136	1057	600	200	550	
GaN [W]	83.73	3.39[D]	3.189, 5.185	1500	656	1500	30	8.9
[Z]		3.2-3.3	4.52					
GaP [Z]	100.69	2.26[I]	5.451	1480	1100	110	75	11.11
GaAs [Z]	144.63	1.43[D]	5.653	1238	460	8500	400	13.18
GaSb [Z]	191.47	0.72[D]	6.096	706	350	5000	850	15.69
InN [W]	128.83	1.89	3.548, 5.703	2146				
[Z]		2.2[(theory)]	4.98					
InP [Z]	145.79	1.35[D]	5.869	1062	700	4600	150	12.56
InAs [Z]	189.74	0.36[D]	6.058	943	260	33,000	460	15.15
InSb [Z]	236.57	0.17[D]	6.479	525	150	80,000	1250	
II-VI								
ZnO [R]	81.38	3.35[D]	4.580	1975	234	200	180	
ZnS [Z]	97.44	3.68[D]	5.420	1827	270	165	5	7.45
ZnSe [Z]	144.34	2.7[D]	5.667	1500	180	540	28	7.6
ZnTe [Z]	192.99	2.26	6.1					9.7
CdS [Z]	144.47	2.42[D]	5.832	1397	270	340	50	8.4
CdSe [Z]	191.37	1.70[D]	6.050	1258	-	800	-	9.7
CdTe [Z]	240.01	1.56[D]	6.482	1097	60	1050	100	10.6
HgS [c]	232.656	-0.17[S]	5.85			250		18 (α-HgS)
HgSe [Z]	279.55	-0.1[S]	6.07			20,000		25.6
HgTe [Z]	328.19	-0.15[S]	6.46			25,000	350	2.1
PbS[R]		0.37				800	1000	161
PbSe[R]		0.26				1500	1500	280
PbTe[R]		0.25				1600	750	360
Ternary								
$Al_{0.48}In_{0.52}As$		1.46			-	900	180	12.9
$In_{0.53}Ga_{0.47}As$		0.75			50	7000	300	12.5

Crystal structure: [Dd]= diamond; [W]= Wurtzite(hexagonal); [Z]= zincblende/sphalerite(cubic); [c] = cinnabar(hexagonal); [R]= rocksalt(NaCl); [D]= direct bandgap; [I]= indirect bandgap; [S]= semi-metal.

N.B.

1. The nitrides are most commonly hexagonal (Wurtzite) rather than the predominantly cubic (zincblende) arsenides and phosphides, affecting the choice of substrate (e.g. 6H-SiC or 3C-SiC).
2. Compounds are grouped by common metal. Within each group, as the atomic number increases (e.g. from nitrides to antimonides) the strength of the bond decreases, causing reduction in bandgap, melting point, heat of atomization, and an increase in lattice constants.

When the atomic number of both elements in the II-VI compounds is increased, the ionicity of the bonds decreases and the bonds become more metallic, i.e. ZnS is almost an insulator; Cd-based binary compounds are narrow-bandgap; Hg-based binaries are semi-metals.

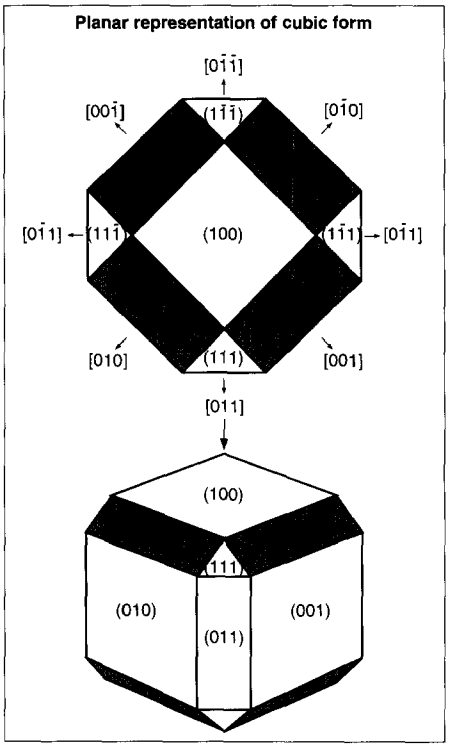
Source: Sze S M, Physics of Semiconductor Devices (Wiley Interscience Publications, NY) 1981, pp848

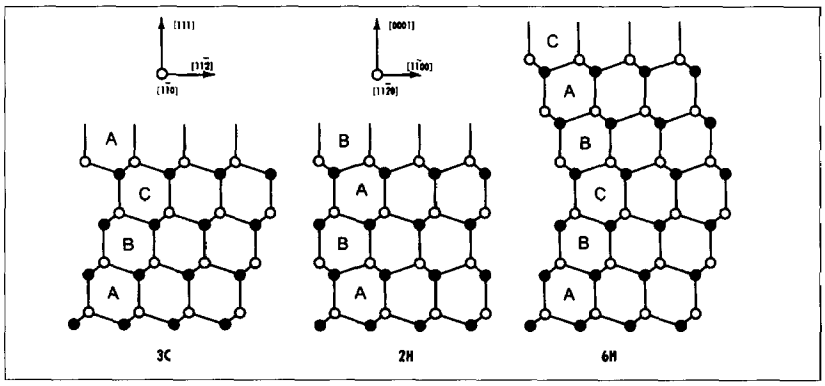
Part of the Periodic Table showing the elements involved in the formation of the semiconductors in Table 1

Group II	Group III	Group IV	Group V	Group VI
	B Boron 5	C Carbon 6	N Nitrogen 7	O Oxygen 8
Mg Magnesium 12	Al Aluminium 13	Si Silicon 14	P Phosphorus 15	S Sulphur 16
Zn Zinc 30	Ga Gallium 31	Ge Germanium 32	As Arsenic 33	Se Selenium 34
Cd Cadmium 48	In Indium 49	Sn Tin 50	Sb Antimony 51	Te Tellurium 52
Hg Mercury 80	Tl Thallium 81			

III-V

II-VI





Stacking sequences for (a) cubic 3C (zincblende), and (b) hexagonal 2H (Wurtzite) and (c) 6H lattices.

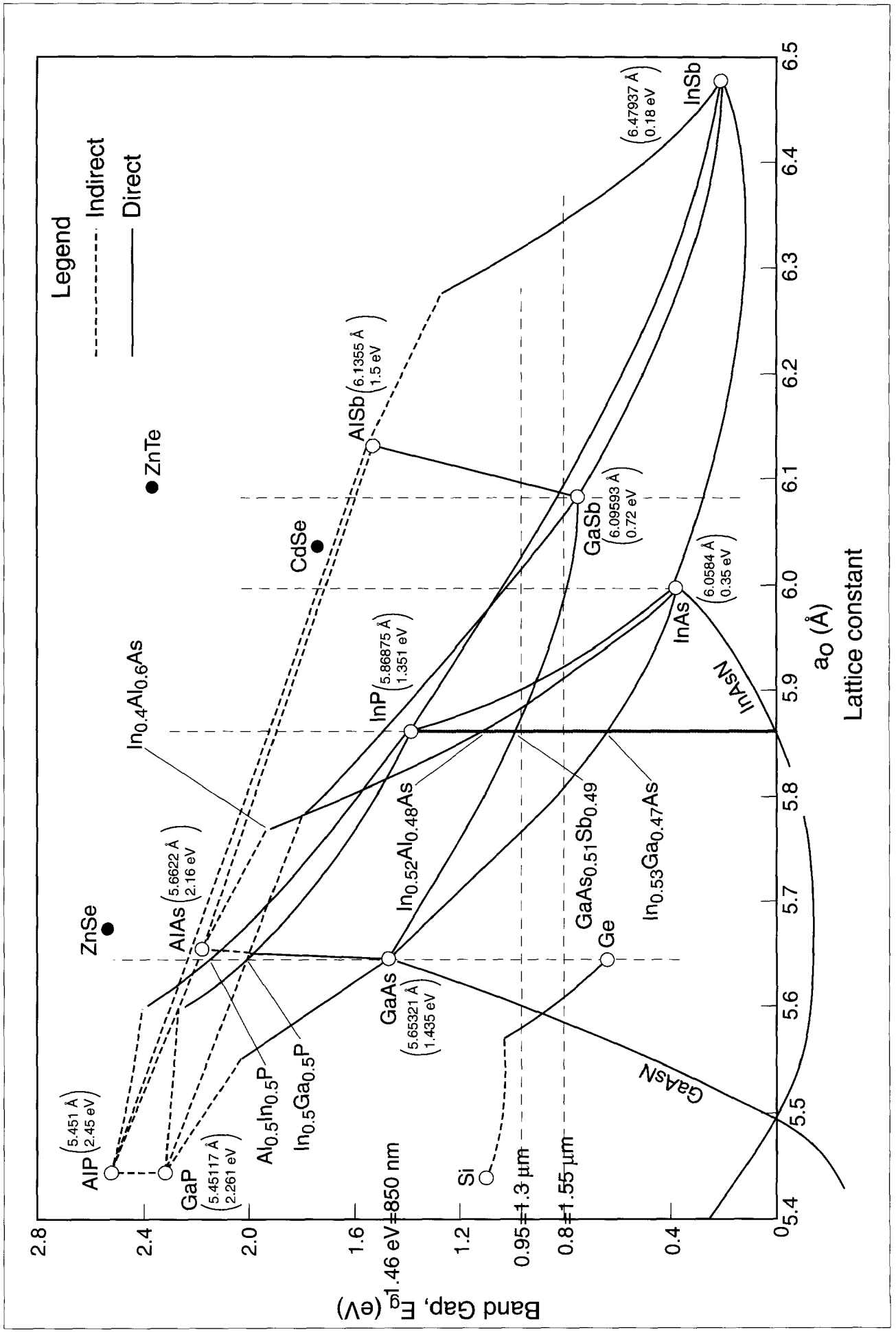
Table 2. Bandgaps of ternary and quaternary compounds

Alloy	Energy gap (at 300K)
Ternaries	
$Al_xIn_{1-x}As$	$E_g(\Gamma) = 0.37 + 1.91x + 0.74x^2$ $E_g(X) = 1.82 + 0.4x$ (for x>0.68)
$Ga_xIn_{1-x}As$	$E_g(\Gamma) = 0.324 + 0.7x + 0.4x^2$
$GaAs_{1-x}Sb_x$	$E_g(\Gamma) = 1.43 - 1.9x + 1.2x^2$
$InAs_{1-x}P_x$	$E_g(\Gamma) = 0.356 + 0.675x + 0.32x^2$
Quaternaries	
$Ga_xIn_{1-x}As_yP_{1-y}$	$E_g(\Gamma) = 1.35 + 0.668x$ $- 1.068y + 0.758x^2 + 0.078y^2$ $- 0.069xy - 0.322x^2y + 0.03xy^2$ $E_g(\Gamma) = 1.35 - 0.775y + 0.149y^2$ (x = 0.47y, lattice matched with InP)
$Al_xGa_yIn_{1-x-y}As$	$E_g(\Gamma) = 0.36 + 2.093x + 0.629y$ $+ 0.577x^2 + 0.436y^2$ $+ 1.013xy - 2.0xy(1-x-y)$ $E_g(\Gamma) = 0.764 + 0.495z + 0.203z^2$ (0.98x + y = 0.47, x = 0.48z lattice matched with InP)

From O Madelung (ed) *Semiconductors: Group IV Elements and III-V Compounds* Springer-Verlag, Berlin, 1991.

Table 3. Fundamental physical constants

Quantity	Symbol	Value
Angstrom unit	Å	$1Å = 10^{-4}$ μm = 10^{-8} cm
Avogadro constant	N_{AVO}	6.02204 x 10^{23} mol^{-1}
Bohr radius	a_B	0.52917Å
Boltzmann constant	k	1.38066 x 10^{-23} $J.K^{-1}$
Elementary charge	q	1.60218 x 10^{-19} C
Electron rest mass	m_e	0.91095 x 10^{-30} kg
Electron volt	eV	1 eV = 1.60218 x 10^{-19} J
Faraday constant	F	9.64867 x 10^4 $C.mol^{-1}$
Gas constant	R	8.31997 $J.mol^{-1}.K^{-1}$
Permeability in vacuum	μ_0	1.25663 x 10^{-8} $H.cm^{-1}$
Permittivity in vacuum	$\varepsilon_0 = 1/\mu_0 c^2$	8.85418 x 10^{-14} F/cm
Planck constant	$\hbar$	6.62617 x 10^{-34} J.s
Reduced Planck constant	$h = h/2\pi$	1.05458 x 10^{-34} J.s
Proton rest mass	M_p	1.67264 x 10^{-27} kg
Speed of light in vacuum	c	2.99792 x 10^{10} $cm.s^{-1}$
Standard atmosphere		1.01325 x 10^5 $N.m^{-2}$
Thermal voltage at 300K	kT/q	0.0259 V
Wavelength of 1-eV quantum	λ	1.23977 μm



Variation of bandgap/wavelength and lattice constant with composition for compounds at (top) red/infra-red and (bottom) orange/ultra-violet wavelengths. Points represent binaries; lines ternaries; areas between lines quaternaries. InGaAsP can reach the 1.3 µm and 1.55 µm fibre transmission wavelengths lattice matched on InP but not on GaAs (whereas InGaAsN on GaAs can); for GaN-based compounds, add In for blue/green or Al for UV.

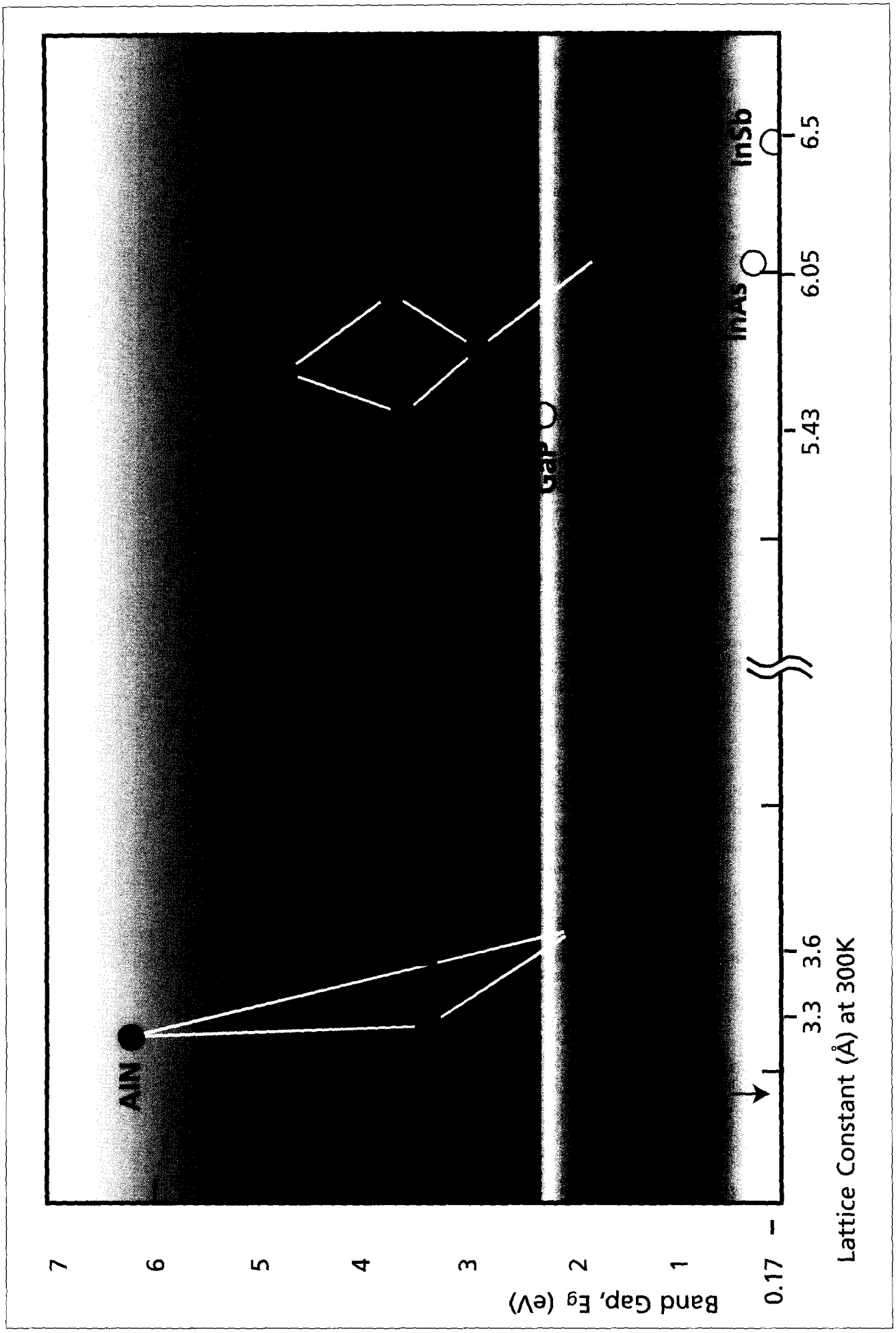


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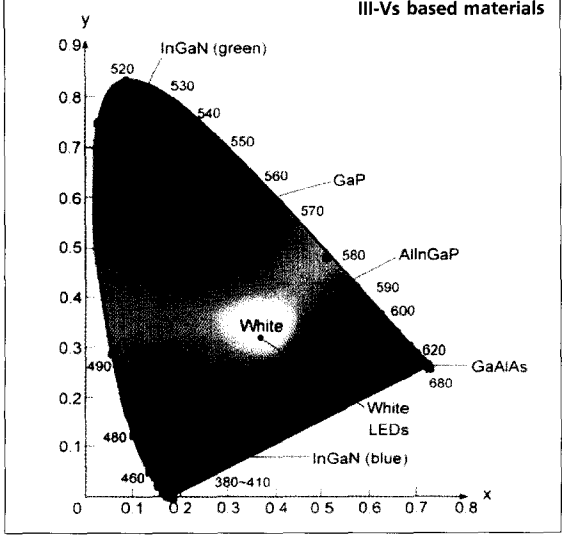
Table 4. List of symbols

Symbol	Description	Unit
a	Lattice constant	Å
B	Magnetic induction	Wb/m^2
c	Speed of light in vacuum	cm/s
C	Capacitance	F
D	Electric displacement	C/cm^2
D	Diffusion coefficient	cm^2/s
E	Energy	eV
E_c	Bottom of conduction band	eV
E_F	Fermi energy level	eV
E_g	Energy bandgap	eV
E_v	Top of valence band	eV
E	Electric field	V/cm
f	Frequency	Hz (cps)
$F(E)$	Fermi-Dirac distribution function	
h	Planck constant	J.s
hv	Photon energy	eV
I	Current	A
I_c	Collector current	A
J	Current density	A/cm^2
J_l	Threshold current density	A/cm^2
k	Boltzmann constant	J/K
kT	Thermal energy	eV
L	Length	cm or μm
m_0	Electron rest mass	kg
m^*	Effective mass	kg
$\bar{n}$	Refractive index	
n	Density of free electrons	cm^{-3}
n_i	Intrinsic density	cm^{-3}
N	Doping concentration	cm^{-3}
N_A	Acceptor impurity density	cm^{-3}
N_C	Effective density of states in conduction band	cm^{-3}
N_D	Donor impurity density	cm^{-3}
N_V	Effective density of states in valence band	cm^{-3}
p	Density of free holes	cm^{-3}
P	Pressure	N/m^2
q	Magnitude of electronic charge	C

Symbol	Description	Unit
Q_a	Interface-trap density	charges/cm^2
R	Resistance	Ω
t	Time	s
T	Absolute temperature	K
v	Carrier velocity	cm/s
v_s	Saturation velocity	cm/s
v_{th}	Thermal velocity	cm/s
V	Voltage	V
V_{bi}	Built-in potential	V
V_{EB}	Emitter-base voltage	V
V_B	Breakdown voltage	V
W	Thickness	cm or μm
W_B	Base thickness	cm or μm
x	x direction	
∇	Differential operator	
∇T	Temperature gradient	K/cm
ε_0	Permittivity in vacuum	F/cm
ε_s	Semiconductor permittivity	F/cm
ε_i	Insulator permittivity	F/cm
$\varepsilon_s/\varepsilon_0$ or $\varepsilon_i/\varepsilon_0$	Dielectric constant	
τ	Lifetime or decay time	s
θ	Angle	rad
λ	Wavelength	μm or Å
ν	Frequency of light	Hz
μ_0	Permeability in vacuum	H/cm
μ_n	Electron mobility	$cm^2/V.s$
μ_p	Hole mobility	$cm^2/V.s$
ρ	Resistivity	Ω.cm
ϕ	Barrier height	V
ϕ_{Bn}	Schottky barrier height on n-type semiconductor	V
ϕ_{Bp}	Schottky barrier height on p-type semiconductor	V
ϕ_m	Metal work function	V
ϖ	Angular frequency ($2\pi f$ or $2\pi\nu$)	Hz
Ω	Ohm	Ω

Chromaticity diagram highlighting the emission of common III-Vs based materials



Relative sensitivity of the human eye